

**UNITED STATES PATENT
APPLICATION
FOR GRANT OF LETTERS PATENT**

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**Method of Presenting Audible and
Visual Cues for Synchronizing the
Breathing Cycle With An External
Timing Reference for Purposes of
Synchronizing The Heart Rate
Variability Cycle With The Breathing
Cycle**

Related Patent Filings:

Method and System for Consciously Synchronizing the Breathing Cycle with the Natural Heart Rate Cycle (10/699,025), Method and System for Synchronizing the Heart Rate Variability Cycle With The Breathing Cycle

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Field of the Invention

The present invention relates to human physiology, and in particular to a method and system for allowing a human subject to consciously control
10 physiological processes, more particularly, it allows a human subject to achieve synchronization of the natural cycle of heart rate with the breathing cycle.

Background of the Invention

15 The human heart is known to have its own nervous system and its own natural tendency toward rhythm. For purposes of this invention, there are two primary aspects to this rhythm, the heartbeat rate, and the rate at which the heartbeat rate changes otherwise known as heart rate variability. Heartbeat rate is usually specified in absolute number of heartbeats occurring during a
20 specified period. Heartbeat rate variability, otherwise know as heart rate variability is the change in heartbeat rate as occurs during a specified period. Henceforth, heartbeat rate variability will be referred to as heart rate variability.

25 While the heart has its own tendency toward rhythm, it is closely coupled to breathing. The relationship is such that as inhalation occurs, the heartbeat rate tends to increase and as exhalation occurs, the heartbeat rate tends to decrease. It is important to note that while the heartbeat rate and breathing rate influence each other, the relationship is a plesiochronous one, that is,
30 they are independent rhythms that strongly influence but do not directly control each other.

It is generally recognized that heart rate variability is an indicator of physiological and emotional state, that is, irregular incoherent heart rate

variability indicates a condition of physiological/psychological stress.

Alternatively, a highly regular coherent heart rate variability is indicative of a condition of physiological/psychological harmony.

- 5 Accordingly, it is highly desirable to achieve and maintain a highly coherent heart rate variability as life circumstances permit. This having been said, with proper training and the application of the present invention, it is possible for a human subject to rapidly achieve the desired state of high coherence of heart rate variability and to reinforce that coherence on an ongoing basis.

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The present invention takes advantage of the relationship between the breathing cycle and the natural heart rate variability cycle to bring heart rate variability to the desired state of coherence and the human subject to the resultant state of physiological and emotional harmony. It accomplishes this via synchronization of the heart rate variability cycle with the breathing cycle. More specifically, it accomplishes this by providing audible and visual cues of varying formats which provide the practitioner with an accurate representation of a timing reference signal to which the breathing cycle is consciously synchronized.

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Summary of the Invention

As previously described, a relationship exists between the heartbeat rate specified in terms of heart rate variability, and the breathing cycle. While the heart has its own tendency toward a natural variable rhythm, there is a strong correlation with breathing according to this specific relationship: as inhalation occurs, there is a tendency for the heartbeat rate to increase, as exhalation occurs, there is a tendency for the heartbeat rate to decrease. In a relaxed or semi-active human subject, the effect of the breathing cycle on the heart rate variability cycle is extremely strong. In fact, the heart rate variability cycle will synchronize with the breathing cycle if the breathing cycle is highly attuned to the periodicity of the natural heart rate variability cycle. The nominal period of the typical human heart rate variability cycle is 11.76 seconds. Therefore, if the period of the breathing cycle is timed to 11.76 seconds, the heart rate variability cycle will synchronize with it, bringing the natural heart rate

variability cycle into phase synchrony with the breathing cycle and thereby bringing the subject's heart rate variability cycle into the desired state of coherence.

5 The present invention accomplishes this by presenting the human subject with various forms of audible and visual cues individually or in combination to which the breathing cycle is consciously synchronized. These audible and visual cues are synchronous signals with a nominal periodicity of 11.76 seconds divided by 2, or 5.88 seconds, representing the 50% of the typical 10 11.76 second heart rate variability cycle and corresponding to 50% of the breathing cycle of like period, that is, the period of inhalation or exhalation. When the breathing is consciously synchronized to this external timing reference signal, the heart rate variability cycle will synchronize with it and remain synchronized as long as the breathing cycle remains aligned with the 15 tuned external reference. In this way, the human subject can remain in the desired state of coherence of heart rate variability for extended periods of time. Ultimately, this builds familiarity with the desired psycho-physiological condition such that synchronization with the external reference occurs subliminally and with continued practice, the state can be realized at will with 20 or without the external timing reference signal.

For purposes of the present invention, we can consider the cycles of heart rate variability, the periodicity of increasing and decreasing of heartbeat rate, and the breathing cycle, the periodicity of inhalation and exhalation, to be two 25 independent cycles. The relative synchronization of these cycles can vary between 0 and 180 degrees. When these cycles are completely out of phase, heart rate variability is maximally incoherent, when these cycles are completely in phase heart rate variability is maximally coherent.

30 Brief Description of the Drawing Figures

The accompanying drawing figures incorporated in and forming a part of this specification illustrate several aspects of the invention, and together with the description serve to explain the principles of the invention.

FIGURE 1 depicts the fundamental periodicity and logical representations of audible and visual indicators of varying utility.

FIGURE 2 depicts various methods of presenting audible information representing the synchronized breathing cycle.

- 5 FIGURE 3 presents an example of music with a tempo and audible cues specifically designed to align the breathing with a period of 5.9 seconds.

FIGURE 4 presents an example of "mantra", a word or phrase that is repeated over and over, again designed to align the breathing with a period of 5.9 seconds.

- 10 FIGURE 5 presents various methods for presenting visual information representing the objective breathing cycle.

Detailed Description of the Preferred Embodiments

- The present invention describes a series of related audible and visual
- 15 methods by which information relating to the periodicity of an external timing reference is conveyed to a human practitioner for purposes of synchronizing their breathing cycle with the external reference signal for purposes of synchronizing their heart rate variability cycle with their breathing cycle. It is understood that these methods may ultimately be instantiated in any number
- 20 of devices employing numerous forms of media including audio tape, compact disk, digital video disk, computers, hardware or software synthesizers, telephones, cellular telephones, televisions or radio broadcast, clocks, watches, and purpose built specialty devices. Secondly, audible forms of the invention may be instantiated in any or all forms of audible media including
- 25 but not limited to music, background ambience generators, clocks of varying variety such as grandfather clocks, alarm clocks, telephones, and audible network based services such as radio stations, internet based services, and purpose built specialty devices. Thirdly, it is understood that there are an
- 30 infinite number of variations possible relative to how an external timing reference may be communicated to a human participant or participants for the purpose of consciously synchronizing the participant's breathing with the external timing reference. The embodiments set forth below represent the necessary information to enable those skilled in the art to practice the invention and illustrate the best mode of practicing the invention. Upon

reading the following description in light of the accompanying drawing figures, those skilled in the art will understand the concepts of the invention and will recognize applications of these concepts not particularly addressed herein. It should be understood that these concepts and applications fall within the scope of the disclosure and the accompanying claims.

The present invention allows a human subject to achieve coherence of heart rate variability by synchronizing the heart rate variability cycle with the breathing cycle. This is accomplished by providing an external timing reference in the form of an audible or visual signal, indicating when the subject should begin inhalation and when the subject should begin exhalation. In some cases, more complete information is provided indicating when the subject should begin inhalation, when the subject should end inhalation, when the subject should begin exhalation, and when the subject should end exhalation. This is repeated in a cyclic fashion, inhalation leading to exhalation, exhalation leading to inhalation, and so forth. The audible or visual reference signal is centered around the nominal frequency of .085 Hertz for a period of approximately 11.8 seconds, the center heart rate variability period of the typical human in a resting or semi-active state. When the typical human subject breathes at this rate, the heart rate variability cycle will synchronize with the breathing cycle, thereby maximizing the coherence of the heart rate variability cycle.

FIGURE 1 presents basic timing and audible and visual functions in a logical format. The most basic information that must be conveyed to a subject or subjects practicing the method is the basic periodicity of the nominal 11.8 second breathing cycle 101, divided by 2, yielding a 5.9 second period of inhalation and a 5.9 second period of exhalation 102. This most basic indication is conveyed in the form of an audible or visual indicator of short duration 103 indicating when to change from inhalation to exhalation or when to change from exhalation to inhalation. 104 conveys this information as a change of phase, that is, a change from inhalation to exhalation or the reverse. Because very exacting coordination of the breath is required, a higher order signal indicating the moment of change as well as the

progression of time is desirable 105. Yet a further improvement that conveys change, progression, and distinguishes between inhalation and exhalation phases of activity is depicted by 106.

- 5 To maximize heart rate variability coherence, it is extremely important that the timing of transitions from inhalation to exhalation and exhalation to inhalation be very exact. For this reason, it is highly desirable to provide the practitioner with audible or visual information such that they can understand breathing progression within a cycle, that is, within the 5.9 second period. By providing
10 information relating to both progression and changes, the practitioner is much more able to align their breathing cycle with the external reference signal in an exacting fashion.

With reference to FIGURE 2, five basic methods for communicating audible
15 information are exemplified. Each method will now be explained. 201 depicts the basic 5.9 second period to which the breath is aligned. 202 is the most basic case representing a tone, chime, or tick conveying information pertaining to the change of the breathing cycle, that is, with each tone, chime, or tick, the breathing cycle changes from inhalation to exhalation or from
20 exhalation to inhalation.

203 depicts the case where information pertaining to both change and progression is provided. This case might be typified by plucking the string of a stringed instrument such as a guitar wherein there is a rapid attack followed
25 by a gradual decay, the rapid attack representing the moment of change of the breathing cycle and the gradual decay representing the progression of the 5.9 second interval. In this exemplary embodiment, the rapid attack occurs every 5.9 seconds. The decay occurs across the 5.9 second interval such that the audio amplitude becomes zero just prior to the next attack, indicating
30 to the practitioner that a change in breathing cycle is imminent.

204 employs frequency modulation as the basis of indicating changes and progression. In this case, an audible tone is varied in frequency, the highest and lowest frequencies indicating the moment of the change in the breathing

cycle from inhalation to exhalation or from exhalation to inhalation, respectively. This method has the advantage of facilitating inhalation with increasing frequency and exhalation with decreasing frequency, a convention that is useful both for audible-only cuing and for combined audible and visual cuing as will be explained later.

205 employs a similar method to that of 204 but using discrete musical notes as opposed as a continuously variable tone. In this example, changes in breathing cycle occur in between the two highest and two lowest notes. In this example, 7 notes are employed to represent the 5.9 second period. It should be noted that 7 notes represents a preferred embodiment of the present invention and that the application of any number of notes within a 5.9 second period provided for purposes of synchronizing breathing either consciously or subconsciously is intended within the scope of this disclosure.

205 provides the same advantage offered by 204, that being the facilitation of inhalation with increasing frequency and exhalation with decreasing frequency. The seven successive notes C, D, E, F, G, A, and B occurring during the 5.9 second period is intentional, the number 7 being used consistently between both audible and visual presentations. Each note is sustained for a period of approximately .84 seconds.

Figure 206 employs the simple method of counting, that is, the recitation of numbers 1 through 7 and 7 through 1. In this example, as in 205, changes in breathing cycle occur in the between the two highest numbers and two lowest numbers. Again this case offers the advantage of facilitating inhalation with increasing number and exhalation with decreasing number.

Referring now to FIGURE 3, an essential embodiment of the present invention involves the adjustment of musical tempo and integration of audible cues into musical scores for the purpose of identifying the beginning and end of the 5.9 second interval such that both singers and or listeners are able to employ the music for purposes of synchronizing their breathing to the audible cues and thereby achieving coherence of their respective heart rate variability cycles. The score of Silent Night, 301 is used for this example. In this case, the tempo

302 is adjusted to allow markers to be inserted at 5.9 second intervals while in keeping with the basic tempo of the musical piece. In this example, chime 303, 304, 305, 306, 307 is inserted every 5.9 seconds 308. The chime or equivalent musical cue can be integrated into the music at the time the music is being played or can be mixed in post recording. Of course, the degree to which the marker integrates pleasantly with the score has to do with the tempo of the music and the degree to which it conforms with the 5.9 second interval.

FIGURE 4 depicts the application of the 5.9 second breathing interval to the repetition of "mantra", mantra 404, 405 typically being a short verse or phrase of spiritual significance that is repeated over and over again. In this example, the 5.9 second interval 406, 407, is delineated by a chime 401, 402, 403 that occurs at the beginning of each 5.9 second interval. The mantra itself may fill this 5.9 second interval as well as span the interval with different verses.

Because both song and mantra are activities in which groups of people often participate, when music or mantra incorporating breathing cues is utilized the heart rate variability cycles of participants are synchronized. This is a nascent field of investigation about which much will be learned via the application of the present invention.

A discussion of visual presentation methods will now ensue. A similar requirement exists for visual indicators as for audio indicators, that is, it is desirable that the visual indicator communicate as much information as is possible about the 5.9 second cycle to the user. This includes changes from inhalation to exhalation and visa versa, whether the phase is an inhalation phase or an exhalation phase, and progression of the 5.9 second interval. Visual indicators may work alone or in combination with audible presentation methods previously described.

Referring to FIGURE 5, the most basic method is represented by 501 which is a simple indication of change of breathing phase, that is, the change from

inhalation to exhalation or visa versa. During the inhalation phase, indicator 502 is highlighted, during the exhalation phase indicator 503 is highlighted.

504 presents a 13 segment indicator that denotes the change of cycle, the present phase of the cycle, that is, inhalation or exhalation, and progression of the cycle. Inhalation is indicated by the transition from 1 to 7, exhalation is indicated by the transition from 7 to 1. It employs the 7 stage convention as did audio examples 205 and 206. This convention and its relevance to breathing and heart rate variability will now be discussed.

10 Preferred audible and visual embodiments of the present invention employ the 7 stage convention with inhalation occurring on increasing number and exhalation occurring on decreasing number. The 7 stage convention conforms to traditional yogic theory of energy planes or centers that exist in the body. When a subject employs the prescribed breathing method, that is
 15 synchronization of their breathing cycle with an external timing reference that is tuned to the natural heart rate variability cycle, the heart rate variability cycle will synchronize with the breathing cycle. When a subject practices this technique for a period of time, there is an internal perception that the energy in the body progresses to these different centers in a fashion consistent with
 20 the cycle of breath. That is, as inhalation occurs, the energy moves from the lowermost center of the body, corresponding to the number 1, 505, to the uppermost center of the body corresponding to the number 7, 506. As exhalation occurs, the energy moves from the uppermost center of the body corresponding to the number 7, 506, to the lowermost center of the body
 25 corresponding to the number 1, 505. As this begins to happen, this energy movement and its location in the body becomes an important dimension of the perceived progression of the breathing cycle. Relative to display 504, each segment is illuminated for 1/13th of the fundamental 5.9 second period or .45 seconds. Because numbers 1, 505, and 7, 506, are representative of both the
 30 end of the inhalation phase and the beginning of the exhalation phase, they are highlighted for 2 consecutive beats.

507 and 508 are simply circular representations of a 7 segment indicator. Sectors are sequentially highlighted from 1 to 7 and 7 to 1. 507 demonstrates

the inhalation phase of the cycle and 508 demonstrates the exhalation phase of the cycle. Each sector is illuminated for $1/7^{\text{th}}$ of the fundamental 5.9 second period or .84 seconds.

- 5 509, an ellipse with 14 defined stages, provides a visual presentation that is also consistent with a traditional yogic paradigm representing the cyclic movement of energy in the body. The same conventions apply to 509 as apply to 507 and 508 except that inhalation occurs as leftmost indicators progress upward from 1, 510, to 7, 511, and exhalation occurs as rightmost
10 indicators progress downward from 7, 511, to 1, 510.

512 defines a specific color coding convention that applies to 13 segment display 504, 7 segment displays 507/508, and cyclic display 511.

- 15 As in the case of music or mantra being engaged in simultaneously by multiple participants resulting in group synchronization of the heart rate variability cycle, the same applies to any form of the invention in which a group can participate including audible and visual forms. These might include school rooms, board rooms, concert halls, etc. This might also include wide
20 area groups including local, regional, national, and global participation via television, internet, and radio broadcast. Again, as this is a nascent field of investigation much will be learned in this regard via the application of the present invention.

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